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A year of Bandipur[1]

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(*With twelve figures, and two plates*)

This is a preliminary report of a year's ecological observations at the Bandipur National Park (11° 39'N, 76° 37'E) in Karnataka. Bandipur is a dry deciduous forest dominated by *Anogeissus latifolia* and *Tectona grandis*. The study area of 23 sq km supported a population of 800 chital (*Axis axis*), 90 elephants (*Elephas maximus*), 20 sambar (*Cervus unicolor*), 40 wild dogs (*Cuon alpinus*), over 10 panthers (*Panthera pardus*) and 10 or fewer tigers (*Panthera tigris*) and a small number of gaur (*Bos gaurus*), barking deer (*Muntiacus muntjak*), wild pig (*Sus scrofa*), and sloth bear (*Melursus ursinus*).

The main rutting season of chital is from May to August, the majority of fawns being dropped between December and February. The death rate of chital is estimated at 92 per cent for the first year and 25 per cent per year thereafter. The fertility rate is estimated at one fawn per adult female per year. Chital form large herds of more than hundred individuals during the monsoon, but these break up into smaller herds of five or six during the dry season. Changes in the herd size of elephants follow a similar pattern. The hunting behaviour of wild dog, which is the major predator of chital is described.

[1] Accepted August 1975.

Introduction

This is a preliminary report of a year's ecological observations at Bandipur. The Bandipur National Park (11°40′-11°55′ N and 76°7′-76°52′ E), covering an area of 689.5 sq km lies at the heart of an extensive forest at the confluence of Western Ghats and Nilgiris. Geologically this area is a part of the archaean crystalline rock formation of the southern part of peninsular India. The terrain is gently undulating with hills rising upto 1500 metres from a basal plateau at an altitude of 1000 metres. The Nilgiri range of hills begins just south of Bandipur, and rises steeply to a height of over 2000 metres within a distance of 25 kilometres.

The National Park of Bandipur is part of a continuous forested tract which includes the wild life sanctuaries of Nagerhole, Wynaad and Mudumalai and the reserved forests of Moyar, Hasanur and the Biligirirangan Temple Hills. The annual precipitation in this tract varies from 3000 to 1000 mm and the forest types consequently range from moist evergreen to dry deciduous. The precipitation at Bandipur itself is only around 1000 mm and the vegetation is largely dry deciduous. This entire forest is very rich in wild life, with elephants, gaur, sambar, chital, barking deer, four-horned antelope, sloth bear, wild pig, grey langur, wild dog, panther and tiger occurring almost throughout the tract. All of these species occur in Bandipur National Park as well, the elephants and chital being particularly abundant.

The present account is based on a year's field work at the Bandipur National Park from May 1, 1974 to April 31, 1975. One of us (HCS) has spent the entire period in field in Bandipur except for a few occasional absences of less than a week. The only exception to this was in June 1974, when a period of three weeks was spent outside Bandipur National Park in visiting the adjacent forests. The second investigator (MG) has spent an average of eight days a month at Bandipur throughout the year. Early morning and late afternoon hours are regularly spent in field observations, totalling three to four hours each day. The work is mostly carried out on foot and the area of intensive observation is therefore restricted to a few square kilometres around Bandipur Lodge. The total study area is *c.* 23 sq km out of the 689.5 sq km area of the park and most of this area is visited twice a week an hour or two at a time in the sanctuary vehicle (fig. 1). Some observations have also been made from elephant back.

Habitat

There is no accurate record of the climate of Bandipur. The bioclimate of the Park has been classified as of the tropical moderate type

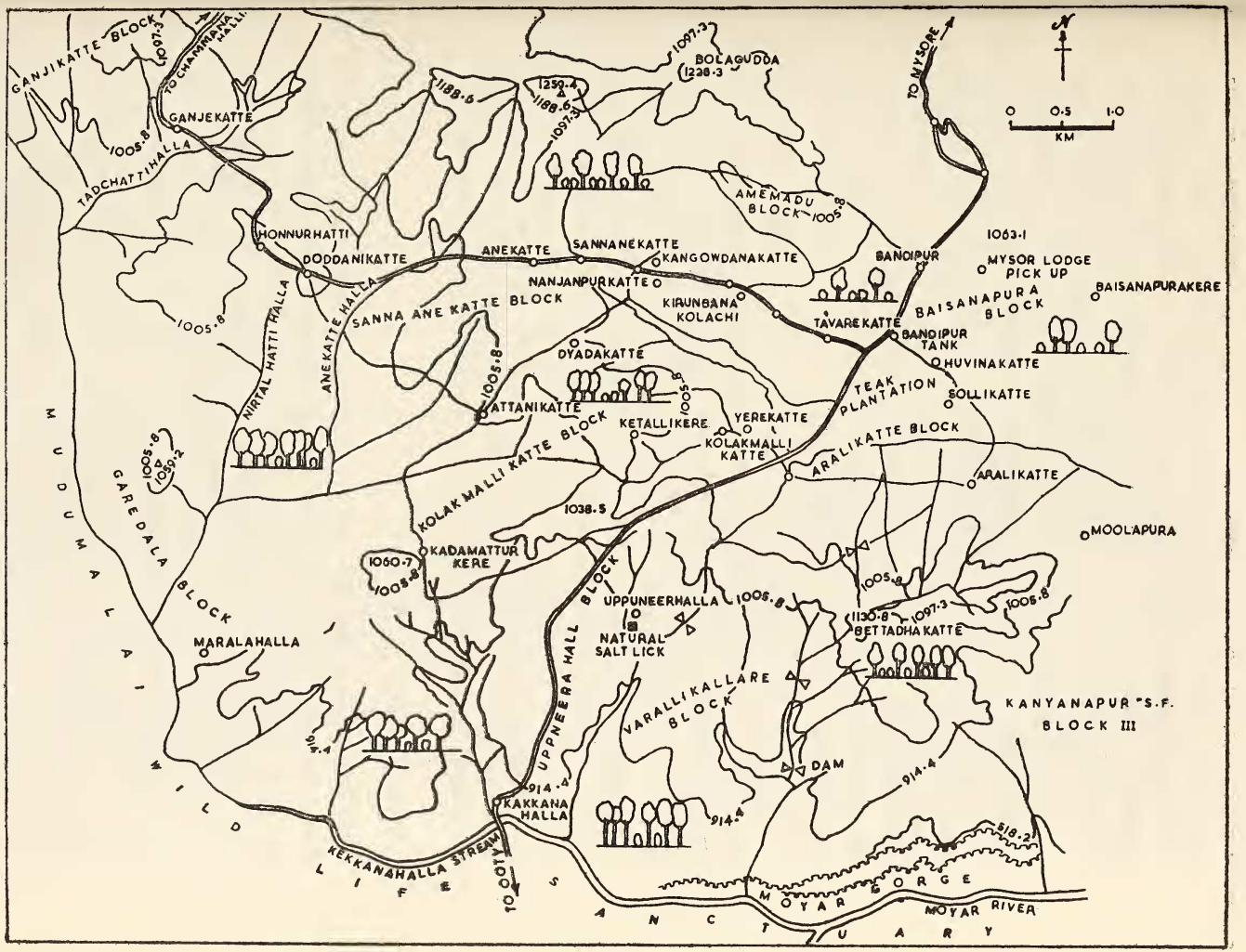


Fig. 1. Map of the area around Bandipur lodge in which most of the field work was conducted. The vegetation profiles diagrammatically represent the height, form and the extent of tree and shrub growth.

(Gaussen, Legris & Viat 1969). The mean annual temperature is less than 24°C and the annual precipitation about 1000 mm, with a range of variation between 750 and 1250 mm. There are heavy pre-monsoon showers in April and May, followed by moderate rains up to September, and another series of heavy showers in October and November.

The vegetation in the study area of 23 sq km belongs to two broad types. The northern half has trees of medium height (10 to 15 metres) with an open canopy and considerable undergrowth (see fig. 2). The major tree species of this locality include *Anogeissus latifolia, Terminalia tomentosa, Phyllanthus emblica, Butea monosperma, Tectona grandis, Terminalia bellerica, Xeromphis spinosa* and *Lagerstroemia parviflora.* The extensive undergrowth is made up of *Lantana camara, Dendrocalamus strictus, Gevotia* spp., *Toddalia asiatica, Argeria cuneata, Asparagus racemosus* and *Cryptolepis buchnani.* The grasses mostly belong to the genera *Heteropogon* and *Themeda.*

There is a sharp north-south gradient of rainfall within the study area, the precipitation increasing as one approaches the steep climb of Nilgiris towards the south. The southern half of the forest therefore enjoys more rainfall and is more moist. The trees are taller, between 15 to 25 metres in height; the canopy cover is more complete, and the undergrowth much reduced. The major tree species include *Anogeissus latifolia, Tectona grandis, Terminalia tomentosa, Dalbergia latifolia* and *Albizzia odoratissima.* There are several major streams in this area, and the stream banks are frequented by *Mangifera indica* and *Bambusa arundinacea.* The shrubby growth is also largely restricted to the stream banks and includes *Lantana camara, Dechaschistia crotonifolia* and *Argeria cuneata.*

In addition to these two major vegetation types merging into each other, there is an extensive open grassy meadow of two square kilometres with scattered scrub and trees near the Tavarekatte area. This has undoubtedly been created in the past through human interference. The species composition is no different for this area except that there are a few patches of the exotic weed *Eupatorium* in the clearing.

The annual cycle of plant growth starts at Bandipur in March and April with pre-monsoon showers, with the grasses coming up and a number of trees sprouting leaves. The grasses dry up after the first flush of growth during the dry spells that follow the first rains. By early May there is enough precipitation for a vigorous growth of grasses and a full production of leaves. This phase of growth continues until October when the grasses begin to seed. With this and the onset of dry season in late November, the availability of herbaceous matter for grazing declines drastically. The trees flower in the dry season, beginning with

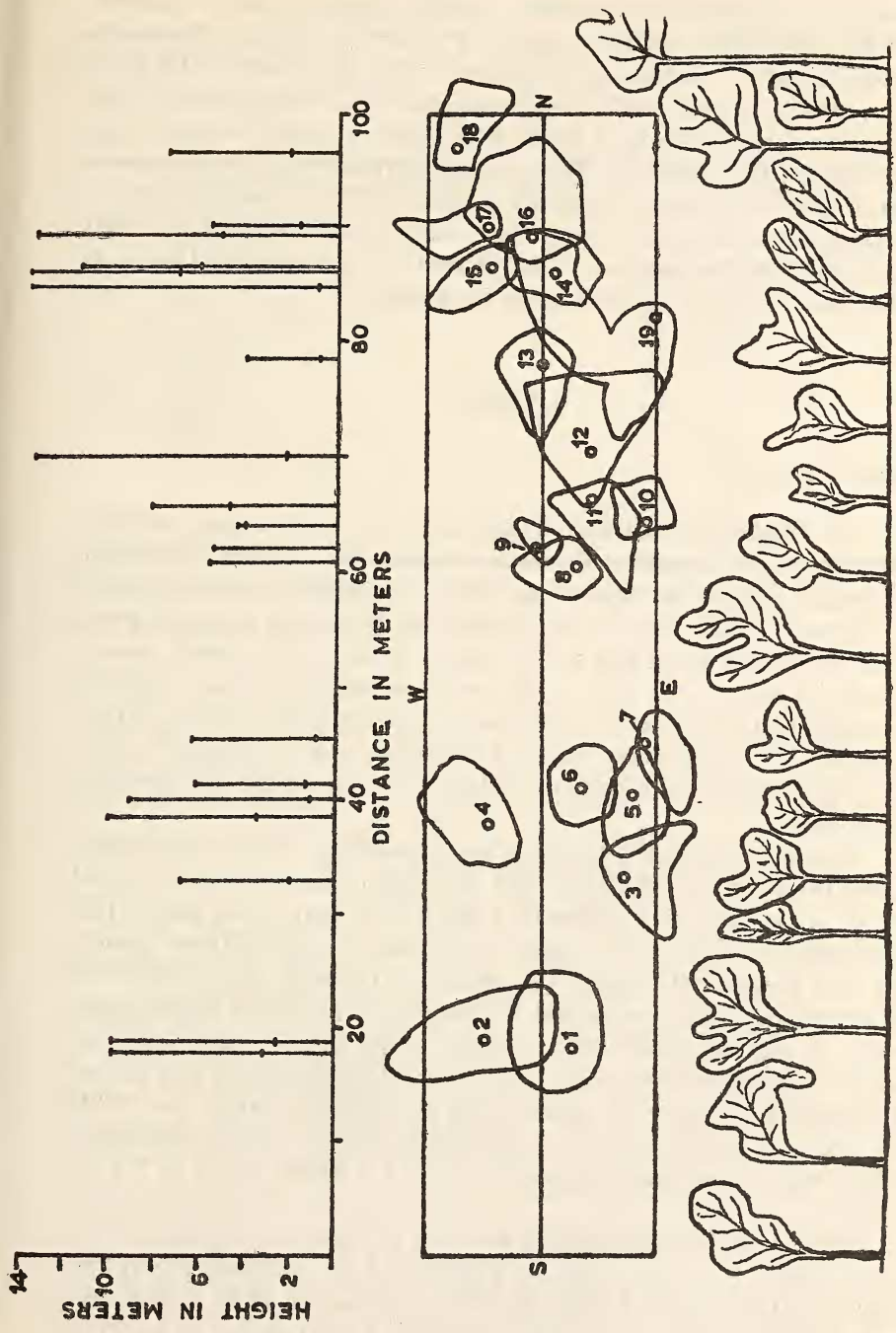


Fig. 2. The vertical profile, the horizontal projection and the form of the trees in a sample area of 100 × 20 metres in the northern part of the study area.

Butea monosperma in November. Several important fruits consumed by the herbivorous animals such as *Phyllanthus emblica, Terminalia bellerica* and *T. chebula* are produced in the dry season. The forest fires, mostly set deliberately begin in January and burn grass over very extensive areas. With these forest fires begins a period of acute food shortage for the herbivores. This is temporarily alleviated by the sprouting of grass with the first showers in March. The dry spells in March-April however bring in serious food scarcity once again. This finally ends only with the persistent good showers in late April and by early May there is plenty of good grass for grazing.

Chital

Habitat preference:

The chital or spotted deer (*Axis axis*) is by far the most conspicuous mammal of Bandipur. Hundreds of them may be seen right within the lodge grounds throughout the night. The habitat of these animals is characteristically the ecotone between the forest and the open grassland. They take much less to the thicker forest with a closed canopy. They also stick to the plains and tend to avoid hilly terrain. Associated with this preference for open grassy glades in forest is their marked preference for grass over browse for feeding, and a tendency to rely on social warning mechanisms rather than camouflage for predator avoidance.

The most extensive grassy patches at Bandipur occur in the region from Tavarekatte to the lodge and the largest concentrations of chital occur in an area of a radius of 2 km in this part of the park. This concentration seems to be made up of four sub-populations, namely (i) two populations around Tavarekatte (ii) one to the southeast of Bolagudda and (iii) one around Ministergutti. The second largest population is also associated with extensive grassy patches near Sollikatte. Two smaller populations occur to the north of Kekkanahalla, and around Kolakmallikatte where the grassy areas are limited in extent (see Table 1). Chital is a very sedentary animal and the deer from each of these areas restrict their movements to a circle of a radius of 1.5 to 2 kilometres.

Table 1 gives our estimate of the total population of chital over the study area of 23 sq km as 800, or a density of 36 individuals per sq km. Following Eisenberg & Lockhart's (1972) estimate of 45 kg as the average weight of a chital, this gives a biomass of 1620 kg per sq km. The chital are however non-uniformly distributed over the total study area, and the Bolagudda area of 2 sq km harbours a population 170, or at

a density of 85 individuals or 3825 kg per sq km. These estimates may be compared to 135 kg per sq km for Kanha in Madhya Pradesh, 263 kg per sq km for Wilpattu in Sri Lanka, and 3960 kg per sq km

Table 1

Estimate of sizes of chital populations at Bandipur

Locality	Population size
Near Bolagudda	170
Tavarekatte I	150
Tavarekatte II	70
Sollikatte	200
Kolakmallikatte	60
Kekkanahalla	100
Ministergutti	80
Total:	830

for Corbett in Uttar Pradesh (De & Spillett 1966, Eisenberg & Lockhart 1972, Schaller 1967).

Daily activity cycle:

The daily activity cycle of chital follows the pattern described by Schaller (1967) for the Kanha population with periods of feeding and social activity in the early mornings and late evenings. This population however has the remarkable habit of congregation of daytime feeding herds into much larger night-time aggregations. These aggregations grow from 1700 hours onwards as the deer herds scattered over five or six sq km for grazing move towards their favourite night-time resting spots where they may form compact concentrations of a hundred or more individuals. They split into smaller and smaller grazing herds in the morning from 0600 hours onwards. The night-time resting spots are open grassy areas. Earlier in the study period, the largest of such open areas was provided by the lodge grounds and over 200 deer used to congregate there at night. Considerable clearing of grasses and shrubs was carried out later in the study period for the provision of view lines along the game roads, and as many deer have started spending the night in these clearings, the number of deer coming to the lodge has sharply declined. Regardless of the number coming to the lodge, however, the proportion of males in the night-time aggregations there has been consistently lower than the proportion in the day-time grazing herds (see fig. 3). It then appears that the males have a tendency to remain closer to the grazing grounds.

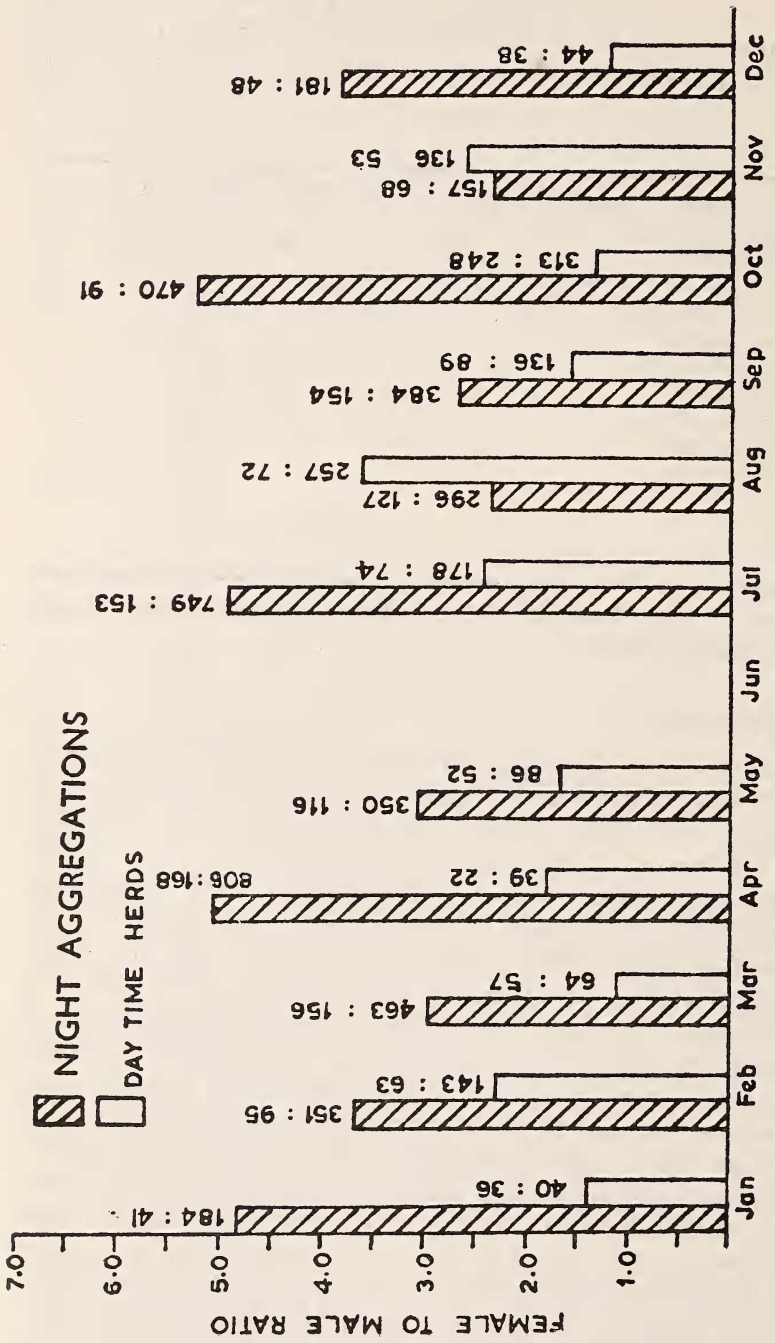


Fig. 3. The female to male ratio in the night aggregations and the day-time herds of chital in various months of the year.

Seasonal cycle:

Feeding

Grasses constitute the preferred food of chital which graze on them even when the grasses are completely dry. They particularly relish the fresh shoots of grasses, and also readily browse on fresh shoots of bamboo, *Lantana, Phyllanthus* and so on. This is supplemented by occasional browsing on a number of other species such as *Acacia arabica, Terminalia tomentosa, Xeromphis spinosa, Butea monosperma, Lagerstroemia parviflora, Barleria retusa, Vitex altissima, Cordia myxa.* It is notable that the chital browse on the highly laticiferous, and to man, poisonous leaves of *Calotropis gigantea.* These leaves are rich in calcium, and this may be the reason for chital selecting them.

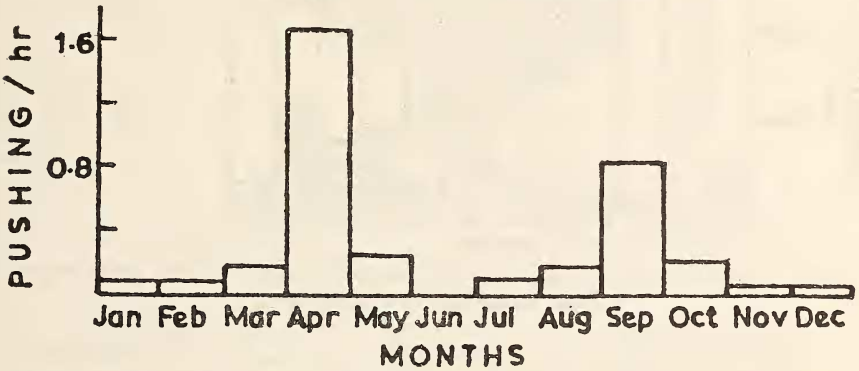


Fig. 4. The number of pushings per hour of observation in the various months of the year for the chital.

As discussed above, the months from May to October provide good grazing on grass and on fresh shoots of various plants. Chital do not have to move much while grazing in this season, and there is little crowding. They graze in large herds, and it appears that their food requirements are rather quickly satisfied, leaving ample time for other social activities. The months from November onwards are difficult with the grasses seeded and drying, and fresh growth of shrubs and trees over. This is however the season of fruiting, and deer feed heavily on fallen fruit. As the season progresses, the food scarcity becomes very acute, especially after the forest fires in January. In this season, particularly from January to March, the deer have to spend a great deal of time looking for food. They move a lot from one bit to another while feeding, and there is much jostling around for food (fig. 4). This jostling is not restricted to males but involves females and fawns as well. They graze in small herds, and seem to spend so much time in feeding that they have little time or energy left for other social activities.

Antler growth

Males of chital grow and shed a set of antlers every year. The cycle probably begins at the age of one year, with the first set of antlers, the spike horns, being less than 25 cm in length. From the second year onwards, they grow a proper set.

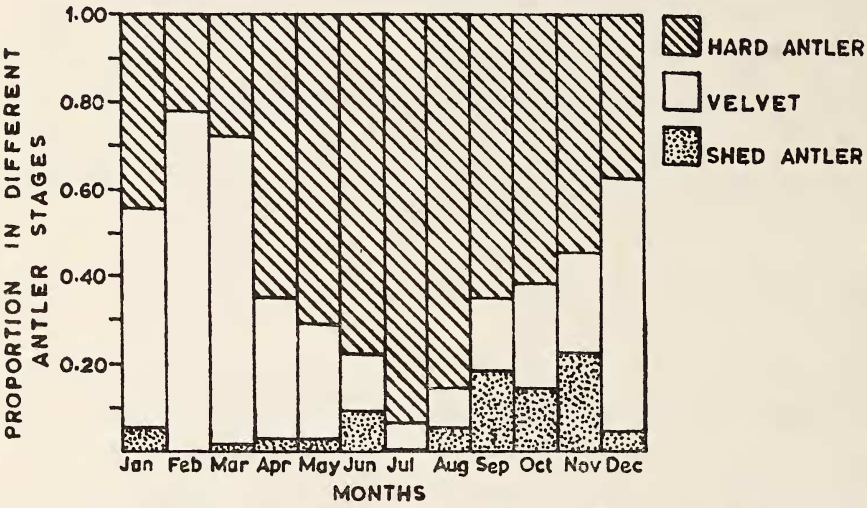


Fig. 5. The proportion of chital males in different stages of antler development for the various months of the year.

Males in all stages of antler development are seen at Bandipur throughout the year. There is nevertheless a distinct seasonality in the development of antlers. As fig. 5 shows, the months of September to November are the months of shedding of antlers, December to February or March are the months of growth of new antlers, and April to August are the months of loss of velvet and a preponderance of hard antlers.

Reproduction:

Males in the hard antler stage are sexually the most active; 90 per cent of all sexual activity is confined to this stage. We would therefore expect the season of marked sexual activity to coincide with the season of the preponderance of males in hard antlers from April to August. As fig. 6 shows, this is in fact the case, and the rutting season of the deer does fall in these months. The gestation period of chital has been variously estimated to range between six to eight and half months. The expected peak of conception from May to July must then result in a peak of fawning between December and February.

Female chital leave the herd around the time of parturition, and keep the fawns hidden in bushes for the first two or three months of their life. The females periodically visit the fawns at this stage to nurse

them, and then leave again to graze on their own. Fawns really join the herds only after two or three months; and hence the proportion of fawns to females in a herd would be at its height only two to three

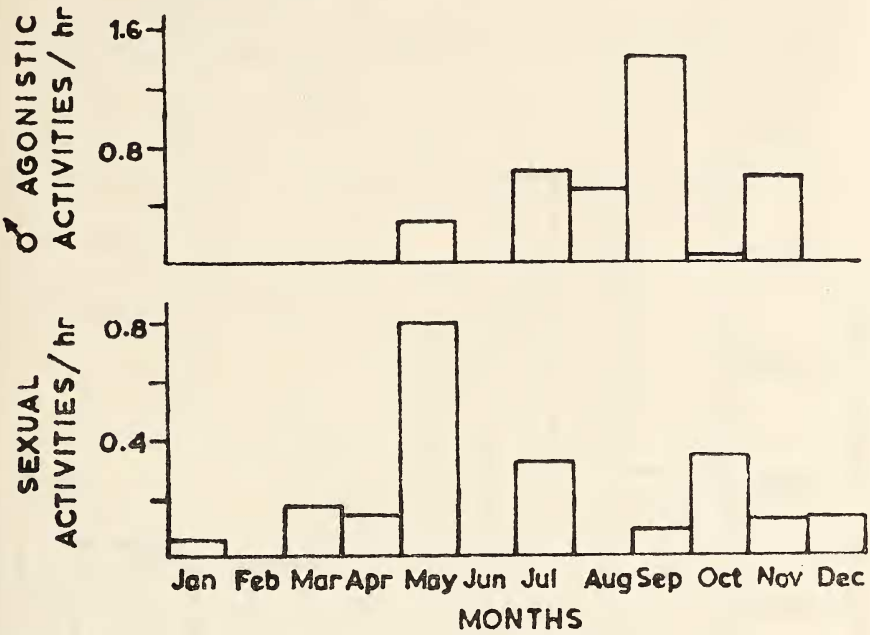


Fig. 6. The number of sexual activities and aggressive interactions amongst the chital males per hour for the various months of the year.

months after their birth. As fig. 7 shows, this peak occurs in the month of April, and must correspond to a peak of births in January-February.

All these data pooled together provide definitive evidence for a seasonality in reproduction of chital. These seasonal trends correspond closely with the trends noted by Schaller (1967) for Kanha and by Graf & Nichols (1966) for Hawaii, and contradict the statement of Krishnan (1972). The seasonality of reproduction must have evolved to fit in with the seasonal changes in the various environmental parameters such as food supply, predation pressure etc. The three critical stages in the life cycle of a mammal are: conception and early foetal development, parturition and nursing of the very young fawn, and weaning and beginning of the independent feeding by the young. These stages centre on the months of July, January and April for the chital of Bandipur. Early foetal development then takes place under good food supply, early nursing under great food scarcity, and weaning of the young just as the tender shoots of grass appear in abundance. This would obviously be optimal if the first and the third stages are the most critical. A final resolution of this issue obviously requires much more investigation.

Predation:

Chital are preyed upon by wild dog, panther, tiger and domestic dog. We have noticed chital hair in the droppings of all four predators. Judging from the quantity of droppings seen, the wild dog is the most significant predator of chital. It preys on all age classes and both sexes of the deer.

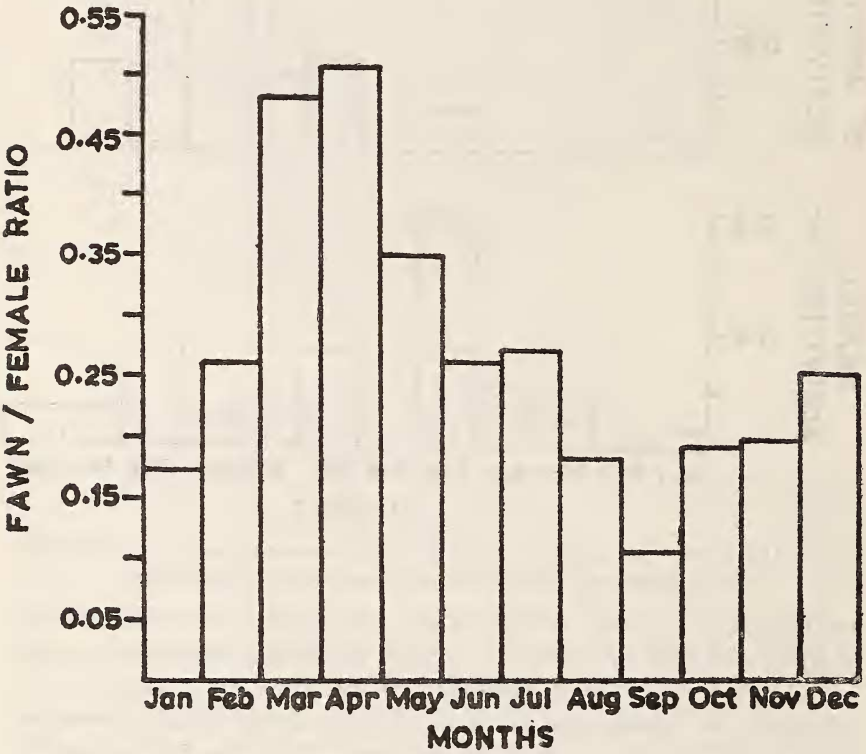


Fig. 7. The ratio of fawns to females in chital for the various months of the year.

Chital respond to the presence of the wild dogs by signalling alarm by raising their tails and then by bunching together. These tight herds start moving slowly away while keeping the wild dogs constantly in view. The chital do not break into a run until the final charge of the wild dogs. When caught, the victim gives out a long drawn wailing call. Even at this point, the chital do not move more than a few hundred metres from the site of the kill. They may then graze apparently totally unconcerned while the wild dogs are feeding on the kill.

Stags with good heads of antlers also fall victim to wild dogs and do not appear to resist in any way. When in a herd, they are the first to run and get into the middle of a herd safely surrounded by females and fawns on all side. One male with hard antlers about 80 cm in length died of drowning in the Tavarekatte pond while trying to escape

wild dogs with one of its eyes injured and with a wound in its hind quarters.

Sex and age composition:

The chital population shows a sex ratio biased in favour of females for most of the months (see fig. 8). In some cases the bias is extreme and is likely to be due to a misclassification of immature males or of adult males in shed antler state as females. Such misclassification is especially likely in large moving herds. In addition, the bias in favour of females may also result from a higher mortality rate amongst the males.

There are two sources of information on the age structure of the chital population. Juveniles less than nine month old are distinguishable as such on the basis of size, although there is room for error. Males growing antlers for the first time at the age of one year grow a distinct type of antlers known as 'spike' antlers. The proportion of the spike males in the population is a reliable estimate of the frequency of the age class of one year. At its highest the fawn to female ratio is a little over 0.5 in April. This compares favourably with the value of 0.68 for Kanha and 0.27 for Corbett. As our estimate of the proportion of females is probably too high, 0.5 may be taken as a minimal estimate. This ratio reaches its lowest value of 0.1 in the month of September (fig. 8). The proportion of spike males in the total adult male population has the maximum value around 0.25 to 0.3.

Mortality rate

The proportion of fawns to the females drops from 0.5 in April to 0.1 in September. As there appear to be extremely few new fawns dropped between April and September we may estimate the mortality over these six months at 0.8, or at the rate of 0.26 per month. As explained above, the fawns are probably born two or three months before April and are mostly kept hidden in bushes. If we assume the mortality to have been around 0.26 per month for these months also, we have the total mortality over the first nine months as 0.91.

The proportion of one year olds in the adult male population has been estimated at 0.25 to 0.3 from incidence of spike males. Now if we assume the survival rate to be constant at some value p throughout the adult life, and the population N to be stable, the proportion of one year olds in the population is:

$$N/N \sum_{x=0}^{\infty} p^x = 1 - p$$

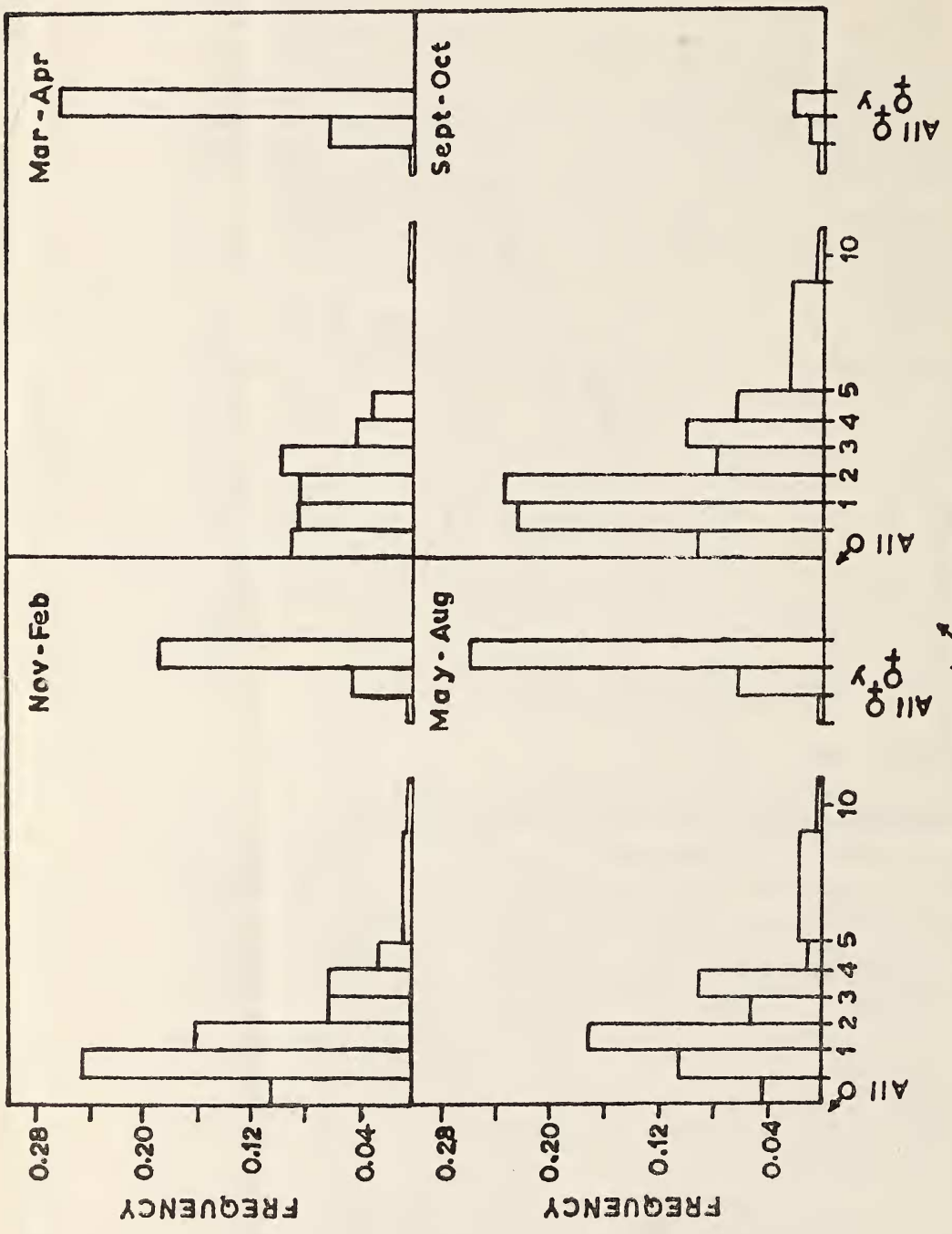


Fig. 8. The sex and age composition of the chital herds at different times of the year ♂ = male, ♀ = female, y = young, ♀y = A herd composed of females and young only.

This gives the estimate of adult mortality rate at 0.25 to 0.3 per year. Assuming this to be the rate of mortality beyond the age of nine months, we get the mortality rate for the first year as 0.92.

Fertility rate

Chital females in captivity start breeding at an age as early as six months and are capable of breeding at intervals of eight months after that. The very distinct peak of fawning at Bandipur however indicates that the females here breed roughly at the interval of one year. Most of the nursing females are accompanied by a single fawn, and twins appear to be extremely rare. Our computation of mortality of fawns suggested a rate of 0.26 per month. The mortality over the first three months may then be estimated roughly at 0.5. The ratio of 0.5 of fawns presumed to be three months old in April to females must then derive from an original ratio of one fawn at birth per adult female. We thus estimate the fertility rate to be one fawn per adult female per year, or assuming an equal sex ratio at birth 0.5 female fawns per adult female per year.

Population growth rate

The growth rate λ of a population may be calculated by solving:

$$1 = \sum_{o}^{\infty} \lambda^{-x} l_x b_x$$

where l_x is the probability of survival to age x and b_x is the number of female offspring produced by a female of age x.

Our estimates are $l_1 = 0.08$ and $l_x = 0.08 \times (0.75)^{x-1}$ for $x \geqslant 1$, and $b_x = 0.5$ for $x \geqslant 1$. We may mention $l_o = 1$ and $b_o = O$ for the sake of completeness. We then have

$$1 = \sum_{1}^{\infty} \frac{0.08\ (0.75)^{x-1}\ 0.5}{\lambda^x}$$

$$= \frac{0.08 \times 0.5}{0.75} \sum_{1}^{\infty} \left(\frac{0.75}{\lambda}\right)^x$$

$$1 = \frac{0.08 \times 0.5}{0.75} \times \frac{0.75}{\lambda - 0.75}$$

$$\lambda = 0.79$$

The population growth rate λ is thus estimated to be less than 1; i.e. the population appears to be declining. This is of course a first estimate which is subject to a number of errors. Our continuing studies at Bandipur will hopefully enable us to verify its reliability.

Herd size and composition:

Chital is a highly social species, and the animals occur only rarely as solitary individuals. Most of the time they occur in herds of 5-20 individuals, though herds of up to 150 animals are not uncommon. The basic unit of the herd appears to be a female and her daughters and perhaps granddaughters, and grandsons. Adult males are only loosely attached to the herds made up of these matriarchal units. Adult males also occur in bachelor herds, particularly outside the breeding season.

There are marked seasonal differences in the size and composition of these herds (figs. 8 and 9). The herds are at their smallest in the season of food scarcity from November to April. At this time herds smaller than 10 including all male herds are usual, and solitary males occur in significant numbers. The herds fragment even further at the time of maximum food scarcity in January-February when herds smaller than 5 animals are very common. These small herds often comprise of females with one or two young. This picture changes radically when the growth of grass begins with the first showers in March or April. Animals then suddenly congregate into much larger herds. However, if the first showers are followed by a dry spell, the grass may dry up, and the food becomes scarce once more. This is immediately followed by a fragmentation of the herds. Only in late April or May do the conditions change more permanently with a lot of plant growth following persistent rain. This is also the beginning of the breeding season which lasts till August. Large herds become very frequent in the breeding season and herds of 40-50 are commonly encountered during the daytime. Males attach themselves to female herds and solitary males totally and bachelor herds almost vanish from the scene. The picture changes again as the rutting season draws to an end in September. At this time the solitary males reappear, and bachelor herds become quite frequent. At the same time the average size of a herd decreases.

These changes in the size and composition of herds appear to be governed by a balance between the conflicting demands of feeding efficiency and predator avoidance, with the balance being different for males and females. Efficiency in predator avoidance presumably increases with increasing herd size. Chital inhabit open country and rely for predator avoidance on a social warning system involving visual signals, warning calls and feet stamping, rather than on camouflage. Animals in a herd are obviously less wary than solitary animals, and seem to be less susceptible to predation. On the other hand feeding

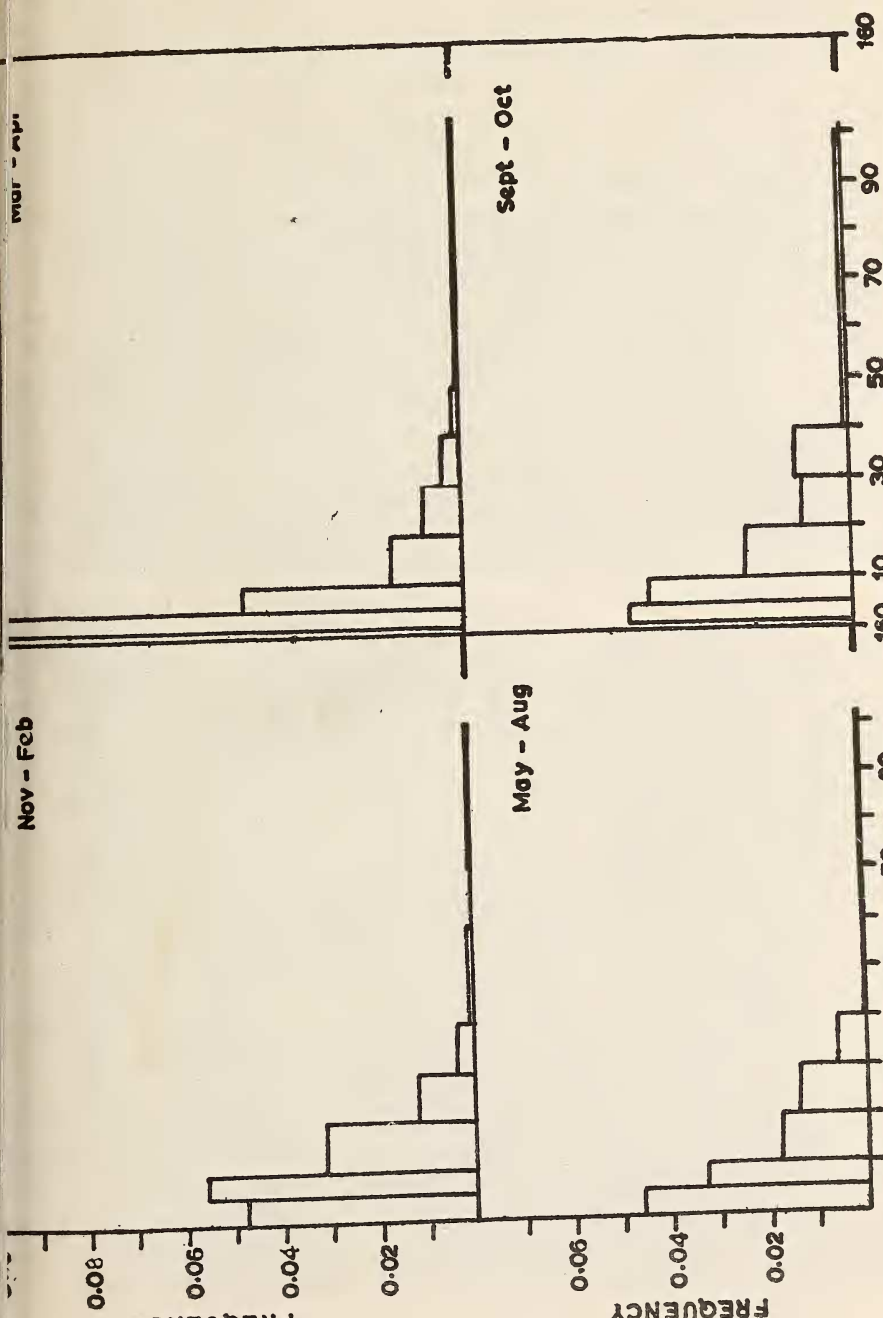


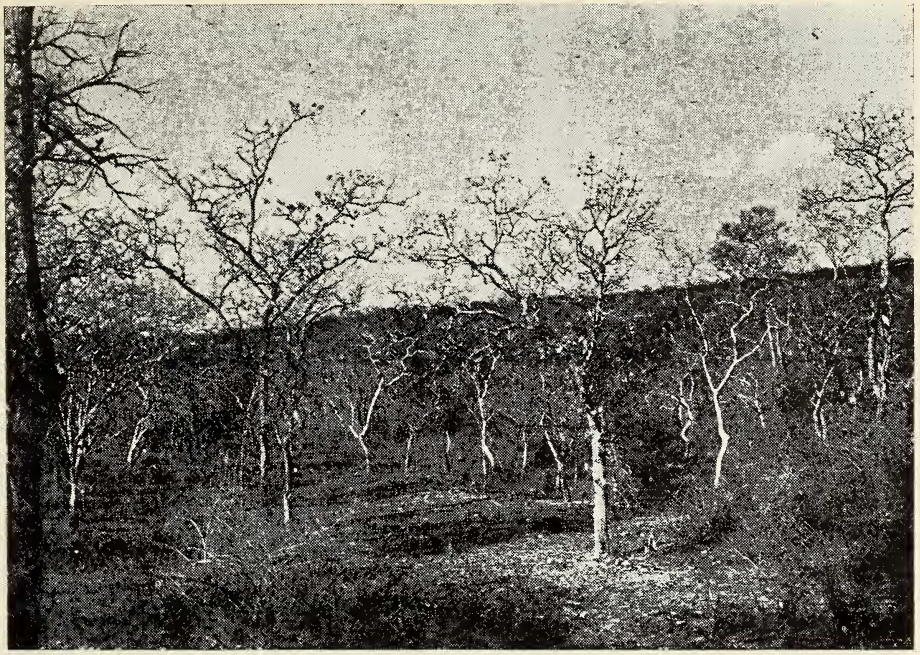
Fig. 9. The frequency distribution of herd size in chital at different times of the year.

efficiency appears to decrease with increasing herd size. There is alw/s a fair amount of interference with each other during feeding of chi.l, and a large number of animals feeding in a small area must lower ıe feeding efficiency. If these assumptions are correct, then the demaıls of predator avoidance should favour large herds, while those of fe ing efficiency should favour small ones. The actual herd sizes must e- sult from a compromise between these conflicting demands. Whene:r the demand for feeding efficiency becomes stronger, the compromıe would be smaller herds, when it weakens the balance would shift)- wards larger herds. The demand for feeding efficiency may be expec d to increase with declining food availability. We would then expect l:- ger herds in seasons of food abundance fragmenting into smaller he s in seasons of food scarcity. This in fact is observed to be the case

The two sexes differ from each other in the relative importance f feeding efficiency and predator avoidance. Chital is a polygynous sp- cies, and as with all other polygynous species there is a fierce male-m e competition for females. A few males at the top of the hierarchy mor- polise mating in such species and this also appears to be the case ı chital. Since the position in the hierarchy crucially depends on physi l growth, feeding efficiency is a very significant component of gene: fitness for the males. On the other hand, all females can and do repı- duce and physical growth does not contribute so significantly to th r reproductive success. The females grow to a smaller size and do rt have the burden of developing a fresh set of large antlers every ye:. Feeding efficiency must then be much less important for the femal.

Predator avoidance on the other hand seems to be more importat for the females. They are much more alert than the males, and mo: apt to investigate the slightest disturbance. This presumably results fro the fact that females are accompanied by their young for much of t: time. Our computations of the mortality rate showed that the you are highly susceptible to mortality, and this must to a large extent l: due to heavier predation. Predator avoidance may therefore be expec ed to be far more crucial to the genetic fitness of the females.

We would then expect females to have a greater tendency to par cipate in larger herds than males. This is in fact the case. Solitary male and small all male herds are much commoner than solitary females- almost never seen—or small female herds. The males seem to attac themselves to females chiefly for the purposes of breeding and solita males or small all male herds are rare only during the breeding-seaso Females are almost always accompanied by fawns and this very muc restricts their movements and that must impair the feeding efficienc to some extent. This is probably the reason for the tendency of the mal to leave the females to form all male herds during the non-breedin season.



Above: In the month of May 1974, towards the Base of Bolagudda from an Elephant back. *Below*: In the month of October 1974, inside the forest (about 9 km from the lodge).

(*Photos*: *Sharatchandra*)

Above: Chital; very close to lodge (July 1974). *Below*: Elephants; near Yerekatte a pond which does not dry up in summer (September 1974).

(*Photos*: *Sharatchandra*)

Chital herds seem to be fairly fluid in composition. We have however twice observed behaviour which suggests that particular animals do tend to stay together. In both these instances a small number of animals behaved as if they had strayed from their herd and appeared to be searching for their missing herd. In both cases the male in the group gave a call similar to the alarm call, but with a longer note. No other deer responded to them. Although the deer saw several other deer, they did not merely join the first herd encountered, but appeared to have waited till they located their own herd.

Other behaviour patterns:

The basic behaviour patterns of chital have been described by Graf & Nichols (1966), Schaller (1967) and Eisenberg & Lockhart (1972), and our observations confirm their results. The Bandipur population however seems to exhibit a much higher incidence of homosexual mountings both amongst males and females, and of agonistic interactions during feeding, particularly amongst females. This may result from the very high concentration of animals, particularly in the most intensively observed Bolagudda sub-population.

Elephant

Population size:

The Indian elephant (*Elephas maximus*) is the dominant mammal of Bandipur although it is abundant only seasonally between April and November. As figure 10 shows, the number of elephants in the study area in the dry season from December to March remains around 40, but increases to 300 in the wet season. The maximum density is thus 13.4 elephants or a biomass of 24254 kg per sq km, while the average density is 3.9 elephants or a biomass of 7059 kg per sq km. This is more than 30 times the biomass of 217.2 kg per sq km recorded for the Wilpattu National Park in Sri Lanka. Our estimate of density is probably too high because the elephants do wander extensively out of the study area of 23 sq km.

While at Bandipur the elephants are concentrated around waterholes like Tavarekatte, Ministergutti, Aralikatte and Kolakmallikatte. Their distribution appears to be governed by the supply of bamboo, tall grass and water. In the dry season the elephants migrate into the wetter forests of Mudumalai and Wynaad.

Age, sex and herd composition:

Out of the total sightings of 854 elephants, 142 were adult males,

59 young males, 436 adult females, 74 young females and 143 calves. This gives a ratio of 2.5 females to 1 male, and a ratio of 0.6 immatures and calves to 1 adult female.

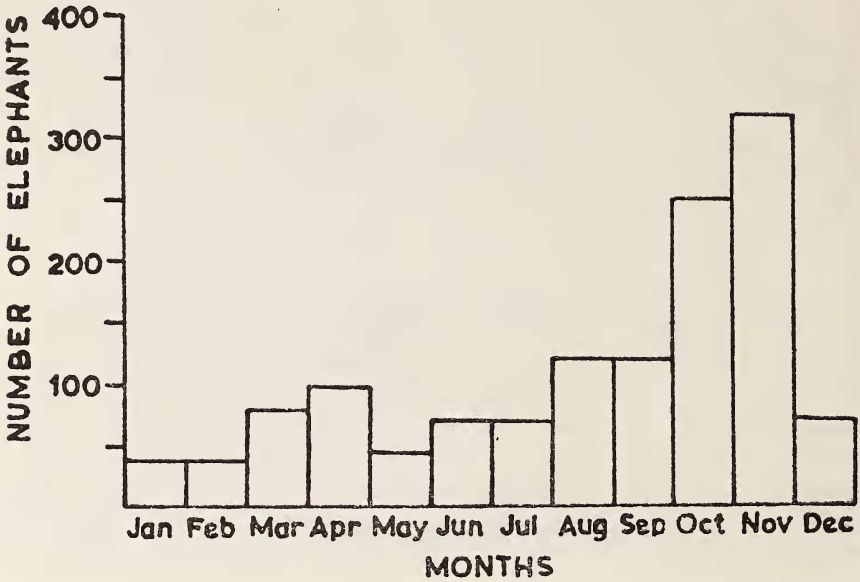


Fig. 10. The total population of elephants in the study area in the various months of the year.

Elephant herds are composed of matriarchal units of one or more adult females, and several immature males and females. These are undoubtedly family units. A herd may include several such units along with loosely attached males. When spread out in grazing the animals within a family unit tend to remain close together, while different units may separate from each other. Elephants generally occur in herds of 10 or less, though herds as large as 80 may be seen. Many such herds often come together at water-holes forming aggregations of as many as 150 animals. Males often occur solitarily, but females never do so (see figs. 11 & 12). As with chital, elephants form larger herds in seasons of food abundance, which fragment into smaller herds in seasons of food scarcity, and the interpretation of these changes appears to be similar to that for chital.

The elephant herds differ from herds of chital in being more cohesive, and in exhibiting co-operative behaviour to a much greater degree. This difference is probably attributable to three factors: (i) The elephants can and do actively defend the babies, while chital rely on hiding them. This provides for much greater scope for co-operation amongst elephants. (ii) An elephant baby may have several siblings born to its mother while it is still dependent on the mother for protection, while chital mature by the time the next sibling is born. (iii) Ex-

perience, for example, of migration routes plays an important role in the life of elephants, while such experience is probably unimportant for a sedentary species like chital. A mature female elephant can then have several immature babies dependent on her to various extents accompanying her. At the same time, she herself may benefit from continued association with more experienced females such as her elder sisters or mother. There is tremendous scope for the evolution of co-operative behaviour in such a group of closely related individuals. In elephants such co-operation seems to have developed particularly for protection of young against predation and nursing of infants.

Female elephants are extremely alert to any source of danger, and

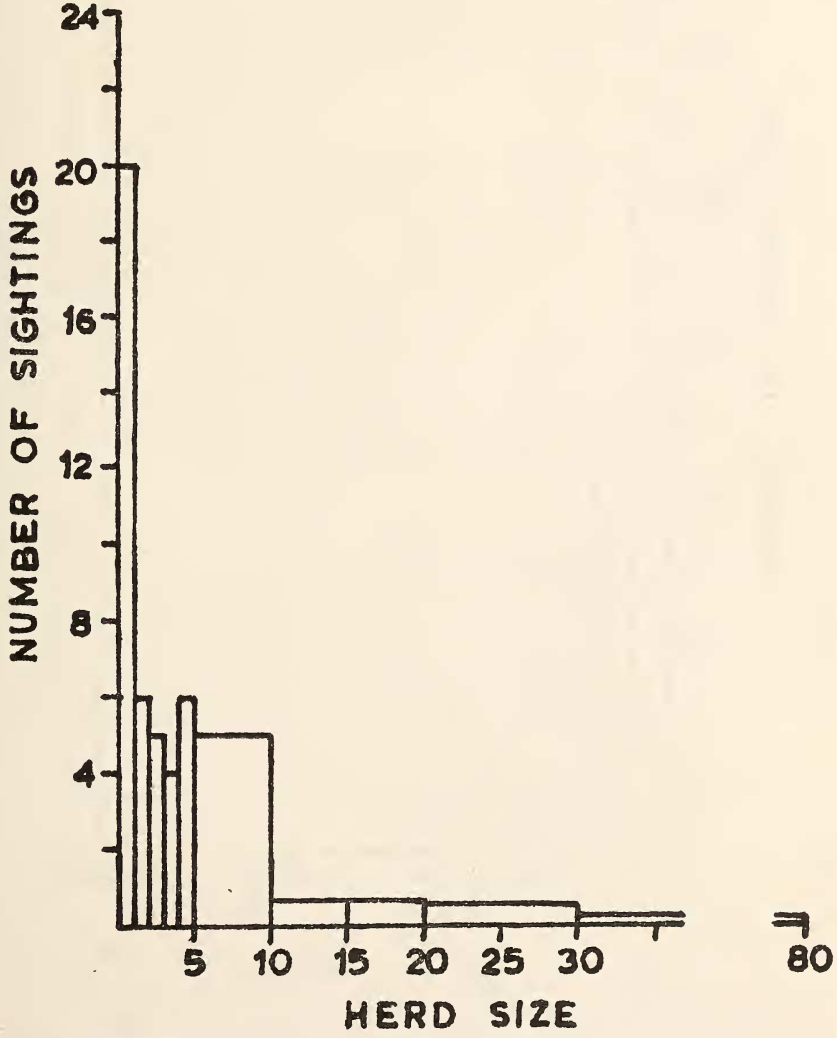


Fig. 11. The frequency distribution of herd size in elephants.

on the slightest disturbance come together, place the babies in between themselves and face the source of danger. This behaviour has been well described by Eisenberg & Lockhart (1972) and needs no elaboration here. The phenomenon of co-operative nursing however seems to be less well documented. Female elephants appear to continue mammary secretion throughout their life after the birth of the first baby. Observations on tame elephants at Bandipur as well as at Mudumalai suggest

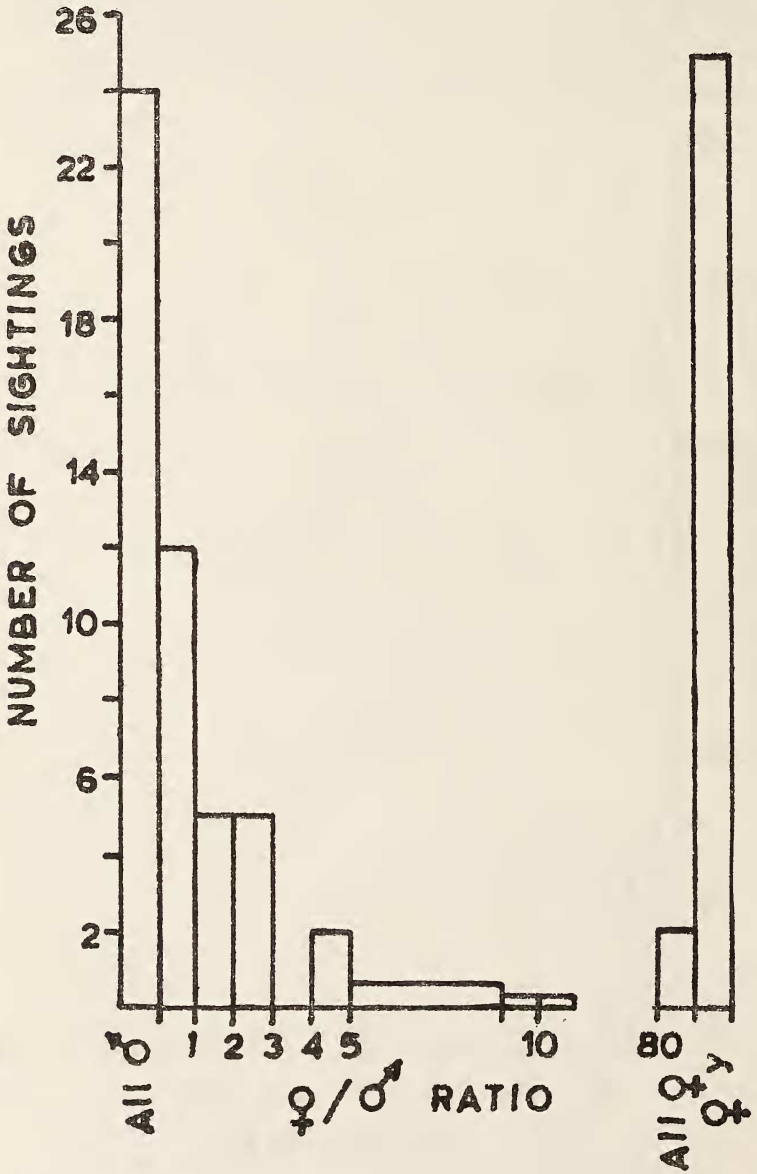


Fig. 12. The composition of the elephant herds. Symbols as in fig. 8.

that mature females without a nursing baby allow other babies to suckle. More remarkably, a mature tame female, Radhika, without a baby of her own showed a swelling of her udders a week before another tame pregnant female Ganga, gave birth to a baby at Bandipur. The swelling of her udders was evidently a response to an impending birth in her 'herd'. All these tame females are in fact wild caught, and are left out in the forest for grazing every day. Their behaviour presumably closely parallels the behaviour of the wild elephants. If this is so, co-operative nursing must be playing a vital role in the rearing up of elephant babies under natural conditions.

Wild dog

Population size:

Amongst the predators at Bandipur, droppings of the wild dog or dhole (*Cuon alpinus*) are noticed in the greatest profusion, and it is probably the major predator of chital and sambar. The actual number of sightings of wild dogs have ranged from 61 in October to none in June, September, November, December and April. Their distribution in the study area appears to coincide with that of chital and sambar. Although it is difficult to estimate their population, our guess based on visual observations of packs is 40 animals for the 23 sq km area, a density of 1.75 animals or 50 kg per sq km. This is a little over 2.5 per cent of the biomass of its major prey, chital.

Pack size and composition:

Wild dogs live in packs of 3 to 30 animals, the occasional sightings of one or two probably being stray animals (Table 2). A lame dog was noticed on three different occasions in the same area, once in a pack of 30, and twice in packs of 10 dogs. This suggests that the wild dog packs must have a certain fluidity, fragmenting and coming together at different times.

Table 2

The number of sightings of wild dog packs

Pack size	1	2	3	4	5	6	10	20	30
Number of sightings	3	5	8	4	–	2	3	1	1

Hunting behaviour:

Wild dogs prey mostly on chital as indicated by their droppings. Kills of chital of both sexes and all ages have been noticed. Kills of full